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(72) Inventors: YUICHIRO IWAI
AKIO SHIMOI
TOSHIKAZU KAWAMURA

(54) IMPROVEMENTS IN OR RELATING TO KEYBOARD ACTUATED ELECTRONIC APPARATUS

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement :

This invention relates to keyboard actuated electronic apparatus and is primarily intended for application to combined timepieces and digital calculators though, as will be seen later, it is applicable to calculators alone (notably table calculators) and other keyboard actuated electronic apparatus.

Keyboard actuated electronic apparatus, such as compact table digital calculators, as at present in common use, have keys which operate switches constituted by reed switches, contact spring switches or similar movement operated switches. This leads to considerable practical difficulties when a so-called pocket calculator is required to be of small size so that the keyboard has to be small. If the calculator is required to be incorporated in a combined wrist watch and calculator the difficulties become so great as to amount, practically speaking, to an impossibility. In general a calculator which performs arithmetical operations requires a considerable number of input keys such as registration input keys (for giving numeral inputs to the calculator), function keys (for selecting different arithmetical operations such as addition or subtraction), a decimal point key, an "equals" key, a "clearing" key and so on. The greater the number of calculating functions, the greater is the number of input keys required. To reduce the size of an electronic calculator to make it small enough to be fitted in a wristwatch is, practically speaking, impossible if the keyboard switches are movement operated, because of the space required for the switch mechanisms. Moreover the switches could hardly be operated by the finger. The elimination of movement operated switches and the use, as the keys of the apparatus of touch switches, that is to say switches which can be operated by touching a fixed part as distinct from switches which cannot be operated except by physically moving a movable part thereof - offers a solution for the difficulty of accommodating movement operated switches in a small space but there remains the difficulty that, if the touch switch keys are very small, the user, in trying to touch a particular key may, if he does not take great care, touch one or more adjacent keys as well and if this happenes the calculator will not work correctly. Incidentally, this difficulty of possible multiple operation of keys arises in a table calculator with movement operated keys, for if the calculator is of small size there is no room for mechanical interlocks for preventing such multiple operation.

The present invention enables a calculator to be made of small size - even small enough to be combined with a wrist watch - by enabling keys constituted by touch switches to be used without incurring the defect of multiple operation of the keys even when the calculator is small enough to make this likely.

According to this invention there is provided a keyboard actuated electronic apparatus comprising a keyboard having keys constituted by touch switches; means, responsive to the touching of a key, for producing a signal which differs, if said key is touched with a relatively large area of finger contact or with a relatively large pressure, from the signal produced if said key is touched with a relatively small area of finger contact or a relatively small pressure; means responsive to the difference between the signals produced when adjacent keys are simultaneously touched, for delaying the signal produced by touching a key which is touched with a smaller area of finger contact or with a smaller pressure, with

respect to that produced by touching an adjacent key which is touched with a larger area of finger contact or with a larger pressure; and means for utilising for operation of said apparatus only the first of the signals produced.

The signals produced are fed to circuitry including MOS or C-MOS elements by means of which the relative delays are obtained.

The touch switch keys may have conductive elements or piezo-electric elements.

The invention is illustrated in and further explained in connection with the accompanying drawings, in which:

Figure 1 is a face view of a combined wrist watch and calculator embodying the invention;

Figure 2 shows a preferred form for the touch switches used in Figure 1;

Figure 3 (which is in three parts namely 3A, 3B and 3C) shows the circuitry used; and

Figure 4 is an explanatory wave form diagram;

Referring to Figure 1, this is a view showing the keyboard and display of an electronic calculator which is incorporated in an electronic wrist watch which also includes timekeeping circuitry and digital time display means. 1 is the case of the wrist watch, 3 is a display device and 4 is the keyboard. The keys of the keyboard are constituted by touch switches which lie almost or quite flush with the face of the watch case the surface of which is continuous. The display device 3 is of the liquid crystal type and, in the example illustrated, has eight display elements. When the apparatus is used as a calculator one of these elements is used to display a calculation function (the left hand one in Figure 1) and the others are numeral display elements. The touch switch keyboard 4 has only twelve keys which are used both as function input keys and as numeral input keys. For example, if it is desired to select the number 9, a key marked [9+] is touched, whereas if it is desired to select the function of addition (+), a function key [F] is first touched and then the key marked [9+] is touched. Thus if it is desired to perform the calculation 7 x 3= , this calculation is effected by successively touching the keys [7S] [F] [6X] [3=] [F] [3=]. 2 is an operation function selector button operating switches by means of which the operation of the combined timepiece-calculator shown in Figure 1 may be selected. In the example illustrated the control button 2 can select between three possible operation functions, namely operation as a timepiece, operation to correct the time displayed, or operation as a calculator. The keys including in their references F, S, T and MD are made use of for correcting displayed time or date (when operating as a timepiece time and date are both displayable) and the same display device 3 serves to give the required display in all operations of the apparatus.

Figure 2 is a sectional view showing a touch switch construction for the keys of the keyboard. Referring to Figure 2, the keys proper (two are shown) are metal keys 5 which are fixed in the case 1 and insulated therefrom by insulating material (shown unshaded) 6. Each individual key is connected to its own connection terminal on a printed circuit board 8 by means of a spring connector 7. The compactness, simplicity and ease of manufacture of this structure as compared with a conventional input switch will be at once apparent, for there are no moving parts or moving switch contacts so that problems of securing water tightness are easy to solve, problems due to bad contacts do not arise and excellent reliability is achieved. Actuation of a key switch as shown in Figure 2 is obtained by merely touching it with a finger tip and thus, in effect, bringing it to earth potential. There is, of course, the element of risk, if the spacing of adjacent keys is made small (because of the small size of the case) that, in seeking to touch a particular key, the user might touch two or more keys simultaneously and thus produce erroneous action. The user would therefore be required to be very careful in touching a selected key. This requirement would be a practical defect. However, because a touch switch operates in effect by detecting the skin resistance of the human body, this defect (producing double or multiple input by touching two or more keys simultaneously) can be largely overcome without difficulty by making the response of the circuit controlled by a selected key dependent upon the size of the area of contact between the finger and that key, so that the circuit controlled by a key which is adjacent to the selected one and which was accidentally touched with a small area contact would not respond.

Figure 3, which consists of three parts, Figure 3A, Figure 3B and Figure 3C, shows preferred circuitry for the calculator portion of the watch/calculator of Figure 1. The block immediately to the left of "Figure 3" and the references "see Figure 3B" and similar references on each of Figures 3A, 3B, 3C show how these figures should be put together to make up the whole Figure 3.

The circuitry consists of a detecting circuit 9 (Figure 3B) comprising the touch keys (two of which are referenced 18 and 19) N-channel MOS field effect transistors (NPN-MOS), and C-MOS inverters of the complementarily connected P-channel MOS and N-channel MOS type; an encoder 10 (Figure 3B); a multiple input prevention circuit 11 (Figure 3A) which gives preference to input signals which first reach it; a binary signal generating circuit

12 (Figure 3A) for securing the display of a numerical selecting input signal by a binary number of four bits, hereinafter termed a "registration"; a shift register 13 (Figure 3A) to which the registration is transmitted; an input control portion 14 (Figure 3C which generates a 1-word cycle signal P once every registration, this signal consisting of digits D_1 to D_9 and being, for example, of a frequency of 448Hz and which includes flip-flops 14*c* and 14*d*, the purpose of which will be describd later; an ROM 16 (Figure 3A); and a further flip-flop 17 (Figure 3A). The circuitry above generally described will be described more in detail later.

Suppose, for example, that, when the user wishes to touch the selected key 18 he also accidentally touches the key 19. Suppose also that touch key 18 is the key for selecting registration 0001, namely numeral 1, and the key 19 is a key for selecting registration 0010, namely 2.

Before the finger tip actually touches a touch key the input terminals 20, 21 of the C-MOS inverters 22, 23 are biased High from a potential V_{DD} through high resistances R_1. The resistances R_2 are protecting resistances for the inverters 22, 23 to prevent damage to the C-MOS input gates by a momentary abnormal voltage caused, for example, by static electricity. These resistances may be about 1M Ω. However, a C-MOS gate has a very high input impedance and is incorporated with a protection circuit consisting of a protection diode and a resistance against momentary abnormal voltage, so that it can endure the application of a momentary abnormal voltage.

Now suppose the tip of the finger touches both the desired key 18 and the adjacent key 19 and consider the voltage level on the input terminals 20, 21 of the C-MOS inverters 22, 23. If the resistance between earth and the finger tip, that is the skin resistance of the human body, is R_S, the input voltage level at the terminals 20, 21 becomes

$$\frac{R_S}{R_S + R_1} \cdot V_{DD}$$

and if $R_S << R_1$, it becomes about zero volts. Experiment shows that, although the skin resistance varies from one person to another it has a value of about 10MΩ or less. Accordingly the resistances R_1 are made of a value which is sufficiently high in relation to 10MΩ e.g. about 22M Ω. Because key 18 is the one intended to be selected the contact area between the finger and this key 18 will be much larger than that between the finger and the accidentally touched key 19. Accordingly the skin resistance affecting key 19 will be correspondingly higher than that affecting key 18 and terminal 21 will take a correspondingly longer time to reach a voltage near zero than terminal 20 will. As shown at (*c*) and (*e*) in Figure 4, the voltage waveform at 21 is delayed with respect to that at 20. After shaping the above waveforms there are obtained at the outputs of the C-MOS inverters 24, 25 in the encoder 10 (Figure 3B) waveforms as shown at (*d*) and (*f*) of Figure 4. When these outputs are passed through OR gate connection means (see Figure 3A) a waveform as shown at *g* in Figure 4 is obtained at point 28 (Figure 3C). This waveform, reversed by an inverter is fed in as the set signal input to an R-S flip-flop 14*a* (Figure 3C) to which a signal synchronous with a 32Hz signal as shown at (*b*) in Figure 4 is fed in as the reset signal. The former signal is freed from chatter and noise by the synchronisation with the 32Hz signal the period of which is longer than that of any chatter or external noise likely to be encountered in practice. Consequently there is obtained at the data input terminal D of a D-type flip-flop 14*c* (Figure 3C) a waveform as shown at (*h*) in Figure 4, i.e. a waveform which is substantially free from noise and chatter. Figure 4 (*i*) shows the Q output at 30 of the D-type flip-flop 14*c* (Figure 3C) and Figure 4 (*j*) shows the Q output at 31 of the flip-flop 14*d*. This is a 448Hz output and is output and is delayed by 1 word as compared with that at 30 and is applied to one input of the NAND gate 32 (Figure 3C) the output from which is shown at *k* in Figure 4.

A signal (CPC) from which a pulse is generated once every word constitutes the reset signal of an R-S flip-flop 11*c* in the multiple output prevention circuit 11 (Figure 3A). A 1-word signal(P) is generated by the D-type flip-flop 14*d* (Figure 3C) and the further flip-flop which is connected with the output of the gate 14*e*. When a funtion key and a decimal point key are touched, the P signal is cut off at the gate 14*e* (Figure 3C). The signal which is applied at F_{k1} is a signal which is changed into the High state or the Low state by touching a function key. There is thus a signal (CPA) which is the topical product of the above mentioned CPC and P signals.

The signal at 28 (Figure 3C) from the OR circuits in Figure 3A is inverted and used as the set signal for another R-S flip-flop 14*b* (see Figure 3C) the reset input signal to which is that shown at *k* in Figure 4. The Q and $\overline{Q}$ outputs of the flip-flop are fed, as shown, to the respective inputs of an AND gate, the Q output being fed to one input of the first gate in the flip-flop 14*b* of which it forms part and being also connected to earth (V_{SS}) through a capacitor. The Q output waveform of flip-flop 14*b* i.e. at 33 is shown at *l* in Figure 4 and the

delayed $\overline{Q}$ output at 34 is shown at *m* in Figure 4. Figure 4*n* shows the waveform at the output 35 of the AND gate. This output is fed to the NAND gate 11*a*, 11*b* (Figure 3A) resulting at point 36 of a waveform as shown at (*o*) in Figure 4 from the former gate, while the output of gate 11*b* (point 38) is held at High and the R-S flip-flop which follows it is therefore not set.

As will now be seen, therefore, only the signal resulting from touching the intended selected touch key is detected and is effected, that resulting from the accidental touching of key 19 being ineffective. This desirable action results from the fact that only the first (the desired) signal of two signals resulting from touching two keys, one of which receives a large area contact with the finger and the other of which receives a small area contact with the finger, is effective, the second signal, resulting from the small area contact being delayed with respect to the first, being inhibited because of its delay. In this way the risk of plural or multiple input is obviated, as is shown in Figure 4 (*n*). The Q output, at 37, of the R-S flip-flop 11*c* is shown by Figure 4 (*p*) and signals other than the desired bit signal 0001 at time T_1 are not transmitted at all. This signal is transmitted as a one word signal to the shift register 13 (Figure 3A). An action as above described takes place even if several keys are simultaneously touched by accident when the user touches a key he has selected. Thus, if, when the user places his finger on key 6X of Figure 1 (for selecting the bit signal 0110 corresponding with the numeral or registration 6) he also touches the adjacent keys 3=, 5÷, 9+ and C, only the intended selected registration 6 will be effectively selected.

Summarising the improvement effected by the invention, it overcomes the difficulty that, with a small dimensional keyboard (such as the keyboard of a calculator incorporated in a combined wristwatch calculator) in which the keys are touch switches, the user is quite likely to touch not only the key he wants, but to touch also (but with smaller areas of finger contact) one or more neighbouring keys. This difficulty is overcome by making use of the fact that the human body skin resistance is different, for an accidentally touched key contacted with a small area of the finger, that the skin resistance present when a key intended to be selected is touched with a larger area of finger contact; converting this difference into a relative delay of a signal resulting from the small area of finger contact; and using this delay to prevent misoperation as a result of touching more than one key at a time.

The invention is not limited to the use of touch keys constructed as shown in Figure 2. For example the keys themselves may be constituted by mere plates let in to the surface of the case 1 instead of being, as shown in that figure, more or less cylindrical bodies. Also any form of touch key as known per se may be used so long as they are sensitive to the way in which they are touched - for example touch keys using piezo-electric elements could be used in place of the merely conductive touch keys illustrated. Such keys are sensitive to what may be termed the shock or pressure with which they are touched and a key intentionally touched will receive more pressure than a key simultaneously but accidentally touched. This difference of pressure or shock can be converted into relative delay by circuitry which is (apart from the keys themselves) the same as that shown in Figure 3 and multiple input can be avoided by said circuitry in the same way as above described for a keyboard with touch keys of the conductive type.

Attention is directed to Patent 1490059 which claims (inter alia) an electronic watch comprising touch-sensitive means mounted on a cover glass and a switching circuit connected to be operated by a change in an electrical property of the touch-sensitive means when the latter is touched, the switching circuit conditioning operation of the watch. Attention is also directed to our co-pending application No. 41754/76 (Serial No. 1573408) which claims related subject matter.

Although the invention has been described as applied to a combined timepiece and calculator it will be obvious that the timepiece portion of the apparatus is really extraneous to the invention which is applicable with advantage to any keyboard operated electronic apparatus where the problem of misoperation by accidental touching of keys additional to the one intended to be touched arises.

WHAT WE CLAIM IS:-

1. A keyboard actuated electronic apparatus comprising a keyboard having keys constituted by touch switches; means responsive to the touching of a key for producing a signal which differs, if said key is touched with a relatively large area of finger contact or with a relatively larger pressure from the signal produced if said key is touched with a relatively small area of finger contact or a relatively small pressure; means responsive to the difference between the signals produced when adjacent keys are simultaneously touched, for delaying the signal produced by touching a key which is touched with a smaller area of finger contact or with a smaller pressure, with respect to that produced by touching an adjacent key. with a larger area of finger contact or with a larger pressure; and means for utilising for operation of said apparatus only the first of the signals produced.

2. An apparatus as claimed in claim 1 wherein the signals produced are fed to circuitry including MOS or C-MOS elements by means of which the relative delays are obtained.

3. An apparatus as claimed in claim 2 wherein the circuitry is substantially as herein described with reference to the accompanying Figures 3A, 3B and 3C.

4. An apparatus as claimed in any of the preceding claims wherein the touch keys include conductive touch elements.

5. An apparatus as claimed in any of claims 1 to 3 wherein the touch keys include piezo-electric touch elements.

6. A pocket calculator constituted by a keyboard apparatus as claimed in any of the preceding claims.

7. A combined calculator and timepiece including a calculator constituted by a keyboard apparatus as claimed in any of claims 1 to 5.

8. Keyboard actuated electronic apparatus substantially as herein described with reference to the accompanying drawings.

J. MILLER & CO.,
Chartered Patent Agents,
Agents for the Applicants,
Lincoln House,
296-302 High Holborn,
London, WC1V 7JH.

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1573409 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

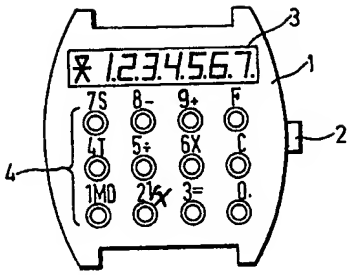


Fig. 1

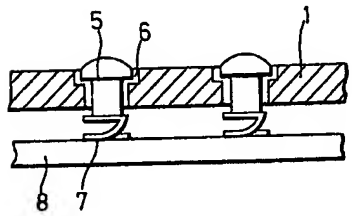


Fig. 2

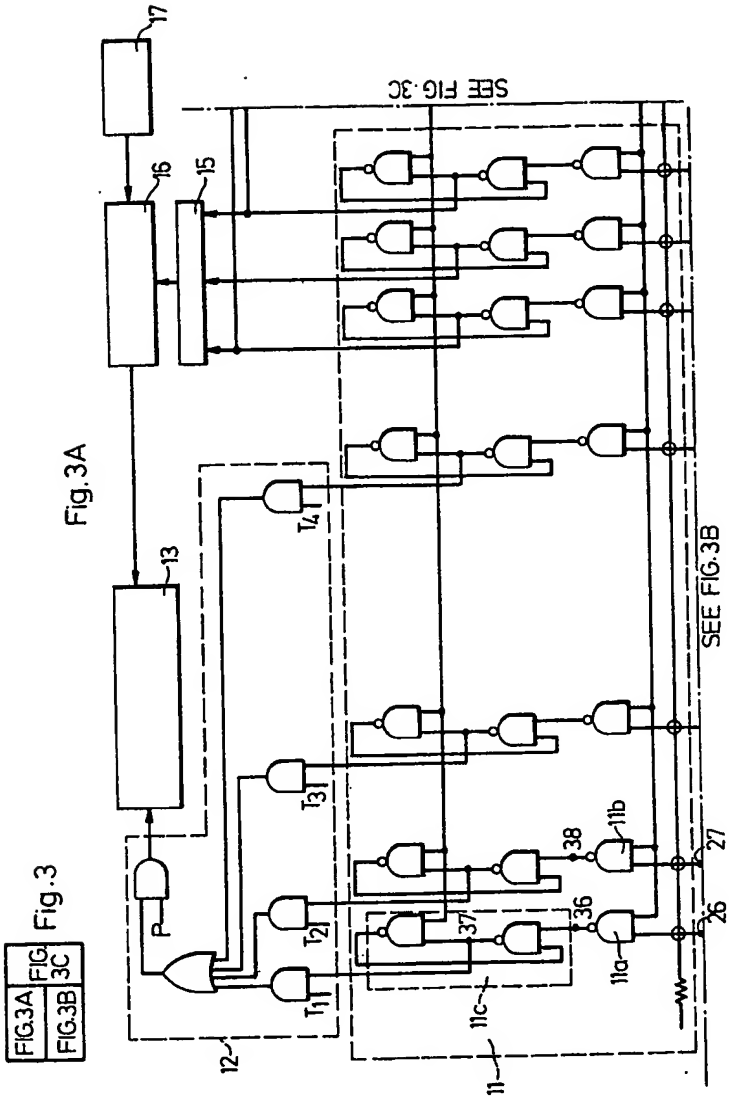


Fig.3A

Fig.3

FIG.3A	FIG 3C
FIG.3B	

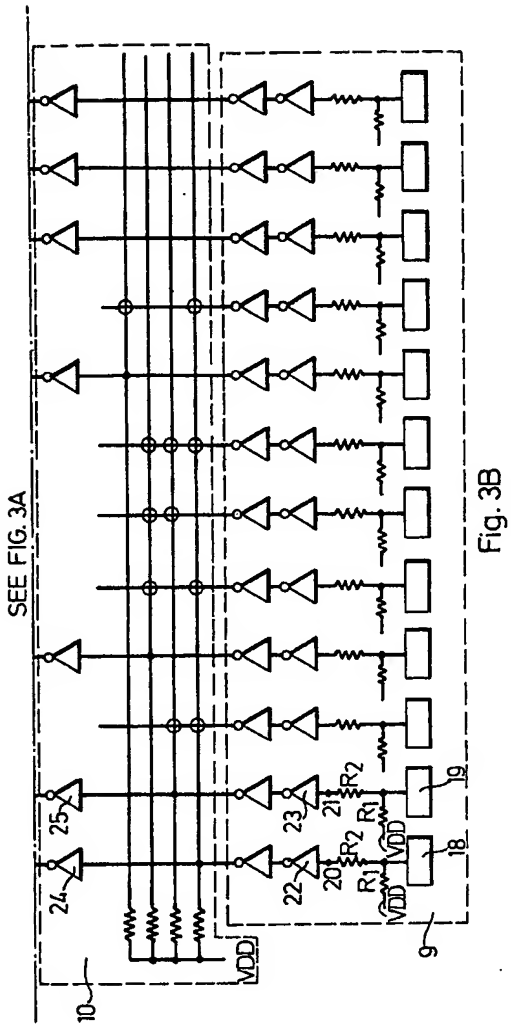
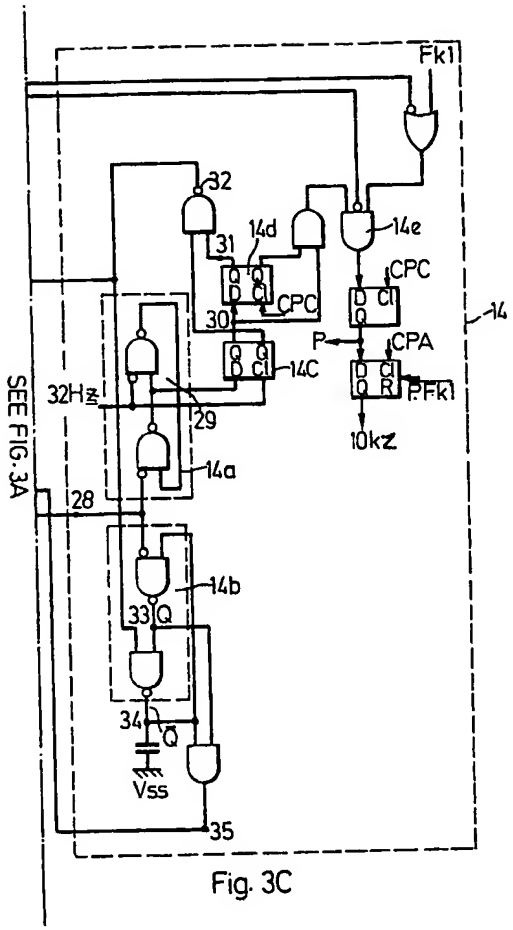


Fig. 3B


Fk1
32
14d
14e
31
CPC
CPC
30
P
CPA
14C
14
32Hz
29
PFk1
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SEE FIG. 3A
14a
28
14b
33
Q
34
Q
Vss
35

Fig. 3C

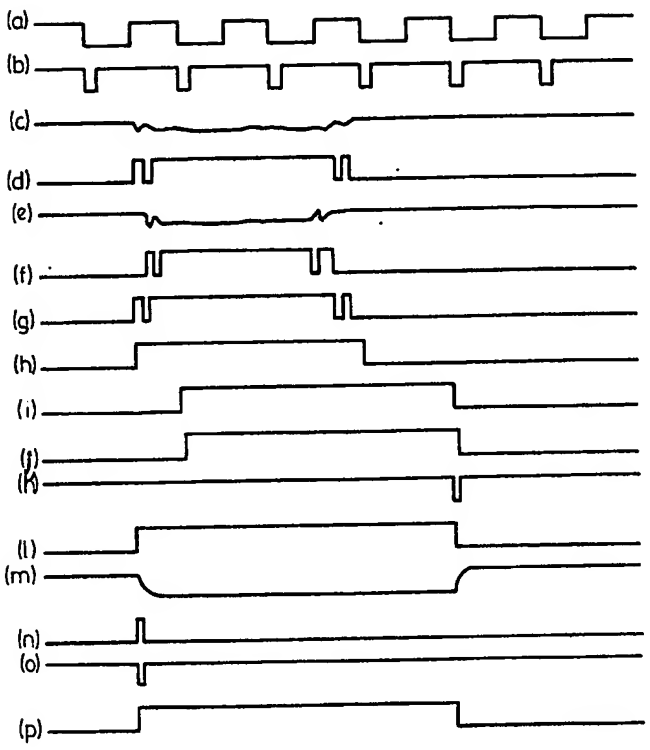

Fig.4